IES Newsletter

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Director's Note

While much of the Institute's research is done at long-term sites at the Mary Flagler Cary Arboretum, field work and collaborative studies are done at many other sites as well, locally, regionally and globally. Field sites in the Adirondack Mountains have been especially important in our long-term studies of lake acidification.

Dr. Paul Bukaveckas, a post-doctoral scientist at the Institute for the past two-and-a-half years, is investigating the effects of acid precipitation in the Adirondack Mountain region from a number of perspectives, and also is testing ways in which lake acidification might be controlled. Several of his ongoing studies are described in this issue of the IES Newsletter.

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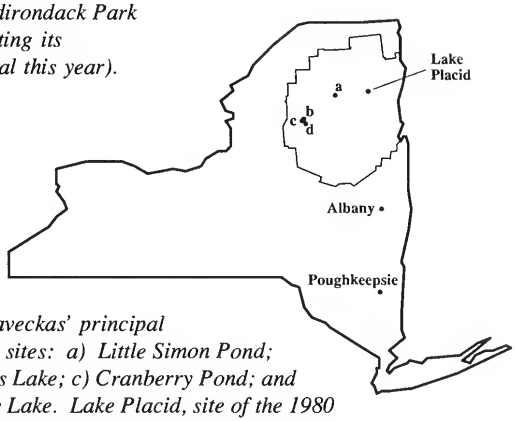
Acid Rain and Adirondack Lakes



New York state, with the boundaries of the Adirondack Park (celebrating its centennial this year).

Dr. Bukaveckas' principal research sites: a) Little Simon Pond; b) Woods Lake; c) Cranberry Pond; and d) Dart's Lake. Lake Placid, site of the 1980 winter Olympic Games, is shown for reference.

What's special about the Adirondack Park? For starters, it's as large as its neighbor across Lake Champlain: the state of Vermont. With 24,000 square kilometers (9,250 square miles) of land, it is the largest park in the lower 48 states. It comprises both publicly owned property and private lots, distinguishing it from the wholly government-owned national parks. Its approximately 130,000 year-round residents and those who maintain vacation homes there share the park lands with animals and plants representing 90% of the species that live in the Northeast. It is a true wilderness, with mountains, mixed forests ... and a lot of water: 48,300 km (30,000 mi) of brooks and streams, 2,400 km (1,500 mi.) of rivers, and over 2,800 lakes and ponds including the source of the Hudson River, Lake Tear of the Clouds.

The Adirondack Park is unique in another way as well: together with the Catskill Mountains to its south, it receives more acidity from precipitation than anywhere else in the United States. This is because the mountain chain is the first elevated land mass in the path of prevailing winds from the Ohio River Valley, a heavily industrialized and urbanized region that releases high levels of sulfur and nitrogen gases[1]. As air currents move east they rise up the mountain slopes and become cooled; precipitation is the result, and the chemicals in the atmosphere make that precipitation acidic.

The Adirondack Mountains are largely granite. Had they been limestone, the high levels of acid deposition perhaps would be buffered to a more normal level[2]. Granite, however, has little capacity to neutralize acids, and this, coupled with the high levels of acidity in the rainfall and the large number of lakes in the area, made the effects of air pollution particularly evident in the park.

The conspicuous changes in the lakes of the Adirondack Park are similar to those observed in acidified lakes in Canada and Europe. First, levels of trace metals in the lake water are several times higher than those measured in non-acidic lakes. Levels of aluminum, a natural component of soils, are especially high because the acidic rainwater dissolves aluminum and carries it from the soil into the lakes. This, then, leads to the second and most visually apparent change: the lakes become clear. In lakes unaffected by acid precipitation, compounds dissolved in the water absorb light and give the water a degree of color. In acidified lakes, however, aluminum binds these dissolved compounds and they sink to the bottom.

Finally, there is a major loss of biodiversity at all levels of the food web, from phytoplankton and zooplankton up to higher plants, amphibians and fish. A non-acidic Adirondack lake, for example, may contain from 30 to 60 different kinds of phytoplankton, while an acidified lake has only from 10 to 15. Of the fish communities, always of limited diversity in lakes, brook trout and other popular sport fish are especially sensitive to acidification, and there are a number of lakes within the Adirondack Park that are so acidic they support no fish at all. What is it about acid rain that is especially harmful to living organisms? This effect is not understood fully, but it is believed that the changes in

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[1] *Sulfur and nitrogen oxides released to the atmosphere react chemically with water molecules to produce sulfuric and nitric acids, leading to "acid rain" and other forms of acid precipitation. The acidity of precipitation is measured on a logarithmic pH scale. On the scale of 0 to 14 with neutral at 7.0, very acidic compounds are at the low end of the scale (lemon juice has a pH of approximately 2 and vinegar of 3) and very basic compounds are at the high end (ammonia: pH 11; lime: pH 12; lye: pH 13). The pH of acid rain is generally in the 2.0 - 5.0 range, while that of "normal" rain is 5.2 or higher.*

[2] *Limestone, or calcium carbonate, reacts with sulfuric acid and nitric acid molecules, thereby buffering the acidity to a more neutral pH.*

pH of the water may be less detrimental than the elevated levels of dissolved aluminum. It is known that aluminum suffocates some species of fish by irritating their gills.

Of the approximately 2,500 lakes in the Adirondack Park that are four hectares (10 acres) or larger in size, approximately 10% are severely acidified. The pH of these lakes, historically in the 5.5 to 6.5 range, is now between 4.5 and 5.0. These lakes are usually surrounded by shallow soils, where rainwater percolates quickly with little time for its acidity to be neutralized. Those lakes whose pH has remained above 5.5 owe their condition to the local geology: they are surrounded by deep soils, especially soils containing limestone. There, percolation of rainwater and snowmelt occurs slowly and allows time for buffering to occur.

IES Research in the Adirondacks

Dr. Paul A. Bukaveckas came to the Institute of Ecosystem Studies in January 1990 as a post-doctoral scientist with a long-standing involvement in acid rain research. His doctoral research at Indiana University concerned the effects of acid rain on Adirondack lakes, and he was interested in linking his data with those collected by IES director Dr. Gene E. Likens at the Hubbard Brook Experimental Forest in New Hampshire's White Mountains[3].

Dr. Bukaveckas has continued his research on Adirondack lakes to learn how acid rain-induced changes in the structure of the lake ecosystem (the numbers of species and/or the numbers of individuals within these species) might affect the functioning of the ecosystem, such as the interactions between species. Dr. Bukaveckas' research focuses on phytoplankton, the microscopic, free-floating plants comprising the base of the lake food web. Lake acidification results in fewer species of phytoplankton and zooplankton. Current research is focusing on how this change in biodiversity affects the efficiency with which food energy is passed from the base of the food web (phytoplankton) to the grazer community (zooplankton) and to higher levels in the food web.

[3] *The Hubbard Brook Ecosystem Study (HBES), in existence since 1963, is at the forefront of long-term ecosystem research. In the early 1970s, as a result of their initial HBES measurements of ecosystem interactions, Dr. Likens and colleagues documented the existence of acid rain in North America.*

Lake Liming Experiment

To learn more about how organisms respond to changes in lake acidity, Dr. Bukaveckas participated in a study in which the pH of three acidic Adirondack Lakes was raised by adding limestone[4]. A fourth site, Dart's Lake, was used as a reference lake and received no treatments. The three experimental lakes -- Little Simon Pond, Woods Lake and Cranberry Pond -- were treated with crushed limestone dumped by helicopter. At Woods Lake and Little Simon Pond, the limestone treatments were repeated three times in order to maintain the desired pH during the course of the eight-year study.

The results reveal a decrease in the amount of trace metals in the limed lakes, and a decrease in water transparency. In the lakes that had been limed the ecosystem structure changed back to what would be considered "normal" in unacidified lakes, with increased numbers of species. The time that it took for the organisms to respond to the improvements in water quality depended on the types of organisms. Phytoplankton recovered in four weeks, zooplankton in four months and aquatic plants in two to four years. Brook trout were stocked and grew rapidly, but did not spawn successfully because the tributary streams where spawning would occur remained too acidic.

Phytoplankton and Zooplankton

Dr. Bukaveckas' research showed that lake liming resulted in an increase in phytoplankton abundance. He speculated that this increase was due to the decline of the grazer community (zooplankton) following the reintroduction of brook trout, which feed on zooplankton. For this to be the case, zooplankton must be important potential grazers in acidic lakes. To test this idea he selected 14 lakes with a range of pH values and set up a simple experiment: lake water, with the zooplankton strained out, was kept for two days in plastic containers submerged in the lake (in order to provide conditions as near as possible to the norm). He then compared changes in phytoplankton abundance in containers with and without zooplankton. The difference represented what would have been eaten if the zooplankton had been present. He found that the effects of removing zooplankton were similar in both non-acidic and acidified lakes, suggesting that zooplankton grazing was not affected by changes in lake acidity.

Dr. Bukaveckas' next question dealt with the zooplankton community itself, and how these organisms responded to changes in lake acidity. He was particularly interested in the group of species belonging to the genus *Daphnia*, crustaceans barely visible to the naked eye and commonly called water fleas. *Daphnia* are very sensitive to even slight increases in lake acidity and also exhibit the highest grazing rates among the many types of zooplankton. On the other hand, copepods -- crustaceans far smaller than *Daphnia* -- can survive in acidified lakes but tend to have lower grazing rates. In order to understand differences in zooplankton grazing in different Adirondack lakes, Dr. Bukaveckas needed to learn more about the species that occurred in his study lakes.

TOM TAFT

Drs. Paul Bukaveckas (r.) and William Shaw are collaborators in a study of plankton communities in Adirondack lakes.

At this point he began what has become a continuing collaboration with Dr. William H. Shaw of Sullivan County Community College (see following article). As the 1991 Cary Summer Fellow, Dr. Shaw examined zooplankton samples under a microscope to identify the species occurring at each site. Dr. Shaw found differences in species composition related to

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[4] *Collaborators were from Syracuse Univ., Cornell Univ., Clarkson Univ., Indiana Univ. and the U.S. Geological Survey (USGS)*

differences in lake acidity. In non-acidified lakes, the zooplankton were larger in size and more diverse, while acid lakes had smaller individuals and only three or four species. Since Dr. Bukaveckas already had determined that the amount of grazing is independent of lake pH, it was apparent that the smaller zooplankton had as great an impact on phytoplankton as did the larger zooplankton. This surprising result has added to the basic understanding of how lake ecosystems work.

The Future of Lake Liming

Is liming an effective way of restoring acidified lakes? It is certainly a successful management technique for improving water quality and restoring biodiversity. However, as more acid rain falls the lakes reacidify quickly, and the repeated treatments required to maintain a more normal pH can present their own negative side effects.

In an effort to find another solution, Dr. Bukaveckas and his colleagues are studying the utility of liming watershed soils. Limestone pellets, dispersed by helicopter over the forested areas surrounding a lake, may provide a longer-term source of buffering. Early data from Woods Lake suggest that the effects of watershed liming on the lake ecosystem were comparable to those observed following direct lake treatment, and that watershed liming could reduce the frequency of treatment. An additional benefit was the improvement in water quality of tributary streams, permitting successful spawning by brook trout.

Early in May, Dr. Bukaveckas began a summer of field work in the Adirondack Park and at Hubbard Brook. His work is supported by grants from the U.S. Fish and Wildlife Service and the Andrew W. Mellon Foundation.

Profile: William H. Shaw

In January 1991, Dr. William Shaw attended a dinner meeting of the Mid-Hudson Biologists held at the Institute's Plant Science Building. With a long-standing interest in freshwater ecology, he had come to hear Dr. David Strayer speak about his zebra mussel research. Dr. Shaw picked up a schedule of Institute Sunday Ecology Programs from the information table, noted with interest an upcoming talk by IES Director Dr. Gene E. Likens on "Human Accelerated Environmental Change", and attended the program. At the end of his presentation Dr. Likens invited anyone interested in current research in the Adirondack Mountains to talk with Dr. Paul Bukaveckas. When Dr. Shaw took Dr. Likens up on his invitation, he had no idea how the direction of his work would be changed.

Dr. William H. Shaw has been a professor of Natural Sciences at Sullivan County Community College in Loch Sheldrake, N.Y. since 1969. As a full-time teacher, Dr. Shaw was limited to doing research that could be done in the basement of his home, during evenings and weekends. When he spoke with Dr. Bukaveckas that Sunday afternoon, the subject of phyto-plankton-zooplankton interactions proved to be one of mutual interest. Dr. Bukaveckas was at the stage in his research (see preceding article) where he needed someone to examine zooplankton samples collected from Adirondack lakes. The collaboration was informal at first, and then Dr. Shaw learned of the research opportunities provided by Cary Summer Research Fellowships.

Cary Summer Research Fellowships are awarded by the Institute to scientists who typically have heavy teaching responsibilities but want the opportunity to do research. Funds are provided by the Mary Flagler Cary Charitable Trust. Dr. Shaw

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Volunteer Recognition Ceremony: "Volunteer support [at the Institute of Ecosystem Studies] is of the utmost importance," began director Dr. Gene E. Likens, adding that the Institute's external review committee has evaluated the IES Volunteer Program as "outstanding". Dr. Likens' remarks welcomed 65 volunteers, staff and friends to the April 23 ceremony — the largest yet, thanks in part to the program reorganization and new recruitment policies by volunteer coordinator Su Marcy. After a catered dinner, the guests learned from Dr. Likens of recent advances in research and education programs and in the display gardens, and enjoyed a slide presentation by Dr. Paul Bukaveckas about his lake-liming research in the Adirondack Park (see the story on page 1).

Su Marcy reported that during the past year IES volunteers ranging in age from 9 to 82 contributed just over 3,288 hours of their time to the greenhouse, display gardens, laboratory and field programs, library, ecology education, gift shop and other areas. Certificates were awarded, and all volunteers who have worked more than 10 hours were presented with an enamel volunteer pin.

Several volunteers received special mention for their long and dedicated service. Betty Stratton (field laboratory, greenhouse, Education Program), was recognized for the assistance she has been giving since 1975. Hilda Messner (Gift Shop), Sally O'Brien (Education Program) and David Smith (Security) have accumulated the greatest number of hours, with 1,030, 1,750 and 2,442 respectively. In recognition of and appreciation for their contributions, Hilda Messner and Sally O'Brien each received an engraved pewter picture frame. (David Smith was unable to attend the ceremony, and his achievement will be recognized at another time.)

Those interested in learning about IES volunteer opportunities are invited to contact Su Marcy at the Education Program office.

From left: Su Marcy, Hilda Messner, IES head of education Dr. Alan R. Berkowitz, Sally O'Brien and Dr. Gene E. Likens

Profile, *from page 3*

applied and was selected to be the 1991 Cary Fellow, enabling him to work with Dr. Bukaveckas throughout the summer.

In addition to examining zooplankton samples at the Institute's microscope facility, Dr. Shaw participated in a field study with Dr. Bukaveckas in the Adirondack Mountains. They compared plankton communities among lakes that differed in their water quality characteristics. Their study sites included closed basin lakes that are dependent upon groundwater inputs and rainfall, and headwater lakes that receive water from inflowing streams and are drained by outlet streams. Through this work the scientists hope to learn more about how water entering from different sources can influence lake ecology. (Results are summarized in the 5th edition of *Discoveries in Ecology*, soon available at the IES Education Program office.)

With much work still to do, Dr. Shaw was able to arrange for laboratory space at the Institute to continue his zooplankton studies. He is now interested in expanding his research to study predator and prey interactions with a view toward understanding how lake acidification affects species interactions within the plankton community.

Dr. Shaw recently was presented with the Chancellor's Award for Excellence in Teaching for 1992. This award is made through the office of the chancellor of the State University of New York system. Dr. Shaw is only the fifth professor at Sullivan County Community College ever to have received this honor.

Summer Calendar

CONTINUING EDUCATION PROGRAM
Summer Semester

June 20: **The Joy of Roses**
June 22, 23, 24: **Basic Residential Landscape Design**
June 27: Field Course: **Ferns of the Northeast**
July 11 (1st of 4 Saturdays): Field Course: **Experiments in Plant Ecology**
July 15: **Summer and Autumn Wildflower Gardening**
July 18: **Organic Lawn Care**
July 27-31: **Illustrating Nature Outdoors**
July 27-31: **Colored Pencil Workshop**
July 25,26: **Introduction to Landscape and Garden Photography**
• *Catalogues describing these programs are available at the Gifford House. Call the number below for registration information.*

SUNDAY ECOLOGY PROGRAMS
Free public programs are held on the first and third Sunday of each month, except over holiday weekends. Programs begin at 2 p.m. at the Gifford House on Route 44A unless otherwise noted. Call (914) 677-5359 to confirm the day's topic.

June 21: **Weather and Pollution Monitoring at IES -- How Do We Do It and Why**, a walk led by Vicky Kelly.
July 19: **A Stream Walk**, led by Dr. Stuart Findlay
Aug. 2: **An Eye on the State of Our Forests,** led by Dr. Gary Lovett
Aug. 16: to be announced
• *For outdoor programs, long pants, socks and sturdy waterproof shoes are strongly suggested. In case of inclement weather, call (914) 677-5358 after 1 p.m. to learn the status of the day's program.*

GREENHOUSE
The IES greenhouse is a year-round tropical plant paradise as well as a site for controlled environmental research. The greenhouse is open during Arboretum hours. Admission is by free permit from the Gifford House.

GIFT SHOP
Senior Citizens Days: On Wednesdays, senior citizens receive a 10 % discount on all purchases (except sale items).
Inventory Sale: 10% discounts in June on all merchandise

ARBORETUM HOURS
(Summer hours: May 1 - September 30; closed on public holidays)

Arboretum grounds are open Mon. - Sat., 9 a.m. to 6 p.m.; Sun. 1 - 6 p.m.
(The Greenhouse closes at 4 p.m. daily.)
The **Gift and Plant Shop** is open Tues. - Sat., 11 a.m. to 5 p.m. and Sun. 1 - 5 p.m.
(Closed weekdays from 1 - 1:30 p.m.).
• *All visitors must obtain a free permit at the Gifford House for access to the Arboretum. Permits are available until 5:00 p.m. daily.*

MEMBERSHIP
Become a member of the Mary Flagler Cary Arboretum. Benefits include a member's rate for IES courses and excursions, a 10% discount on purchases from the Gift Shop, a free subscription to the IES NEWSLETTER, and parking privileges and free admission to the Enid A. Haupt Conservatory at The New York Botanical Garden in the Bronx. Individual membership is $30; family membership is $40. For information on memberships, contact Janice Claiborne at (914) 677-5343.

For more information, call (914) 677-5359 weekdays from 8:30 - 4:30.

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